

NEXT-100 Operating Pressure, 100 kg Total Xe

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Mass of Xenon in Vessel at Maximum Operating Pressure (absolute):

We presently have a total of 100 kg Xe. if we do not obtain more then our maximum operating pressure (assuming we have negligible volume in gas purification system, including recovery vessel) is then computed as follows:

Pressure vessel has internal dimensions length, radius:

$$L_{pv} := 2.1\text{m} \quad R_{i_{pv}} := 57\text{cm}$$

Total Vessel internal volume is :

$$V_{ves} := 2.001\text{m}^3 \quad \text{from CAD measurement (no nozzle vol; assume all but one nozzle are mostly filled; we will add 2 nozzle vols to main vol)}$$

$$V_{noz} := \pi 5\text{cm}^2 \cdot 32\text{cm} \quad V_{noz} = 5.027 \times 10^{-4} \text{m}^3$$

Internal component volume sum

PMT enclosures (cans)

$$r_{o_{can}} := 4.4\text{cm} \quad l_{can} := 16\text{cm}$$

$$v_{can} := \pi r_{o_{can}}^2 \cdot l_{can} \quad v_{can} = 9.731 \times 10^{-4} \text{m}^3$$

$$v_{cans} := 60 v_{can} \quad v_{cans} = 0.058 \text{m}^3$$

PMT mounting plate

$$v_{mp} := .0104\text{m}^3 \quad \text{from CAD measurement}$$

SiPM electronics shield

$$v_{sh} := .086\text{m}^3 \quad \text{from CAD measurement}$$

Assume field cage, mesh frames and SiPM boards are negligible

Net internal volume:

$$V_{int} := (V_{ves} + 2V_{noz}) - (v_{cans} + v_{mp} + v_{sh}) \quad V_{int} = 1.847\text{m}^3$$

Total amount of xenon

$$M_{Xe_{100}} := 100\text{kg}$$

Operating Temperature, physical constants:

$$T_{amb} := 293\text{K} \quad R := 8.314\text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \quad M_{a_{Xe}} := 136\text{gm} \cdot \text{mol}^{-1}$$

Critical Pressure, temperature of Xenon:

$$P_{c_{Xe}} := 58.40\text{bar} \quad T_{c_{Xe}} := 15.6\text{K} + 273\text{K} \quad T_{c_{Xe}} = 288.6\text{K}$$

reduced pressure:

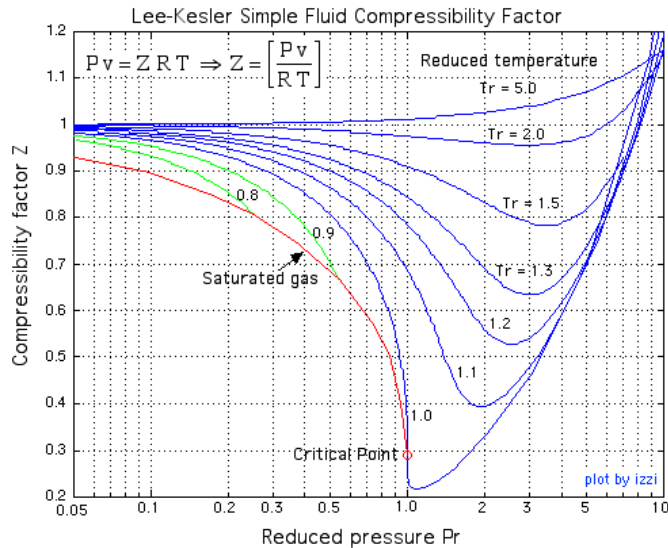
$$P_{r_{8bar}} := \frac{9\text{bar}}{P_{c_{Xe}}} \quad P_{r_{8bar}} = 0.154$$

reduced temperature

$$T_r := \frac{T_{\text{amb}}}{T_{c_Xe}} \quad T_r = 1.015$$

Compressibility Factor: from chart for pure gasses shown below

$$Z_{Xe_9\text{bar}} := .94$$



ref: A Generalized Thermodynamic Correlation based on Three-Parameter Corresponding States, B.I.Lee & M.G.Kesler, AIChE Journal, Volume 21, Issue 3, 1975, pp. 510-527' (secondary ref. from: <http://www.ent.ohiou.edu/~thermo/>)

Fig. 6 Compressibility Factor, pure gasses

Number of moles:

$$n_{Xe_100} := \frac{M_{Xe_100}}{M_{a_Xe}} \quad n_{Xe_100} = 735.294 \text{ mol}$$

Operating pressure is:

$$P_{100\text{kg_tot}} := \frac{n_{Xe_100} \cdot Z_{Xe_9\text{bar}} \cdot R \cdot T_{\text{amb}}}{V_{\text{int}}} \quad P_{100\text{kg_tot}} = 9.1 \text{ bar}$$

Density is:

$$\rho_{100\text{kg_tot}} := \frac{n_{Xe_100} \cdot M_{a_Xe}}{V_{\text{int}}} \quad \rho_{100\text{kg_tot}} = 0.054 \frac{\text{gm}}{\text{cm}^3}$$

Mass of xenon in active volume

$$l_{\text{av}} := 1.3\text{m} \quad r_{\text{av}} := 53\text{cm}$$

$$V_{\text{av}} := \pi r_{\text{av}}^2 \cdot l_{\text{av}} \quad V_{\text{av}} = 1.147 \text{ m}^3$$

$$M_{\text{av}} := M_{Xe_100} \cdot \frac{V_{\text{av}}}{V_{\text{int}}} \quad M_{\text{av}} = 62.1 \text{ kg}$$